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The effect of renewable energy on employment. The case of Asturias (Spain)☆

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Abstract

Several changes are taking place in the energy sector as a result of the development of renewable energies and the implementation of new clean technologies.

The use of renewable energies offers the opportunity to diminish energy dependence, reduce the emission of CO_2 and create new employment. The involvement of local agents is highly important for the future development in this field, especially in regions whose industrial mix was based on traditional energy sources. Since this is the case in the region of Asturias (Spain), in this article we focus on the expectations of employment generated by renewable energies in Asturias during the period 2006–2010. More specifically we propose ratios of job per unit of installed energy power based on the available regional information in order to forecast energy employment in Asturias. With this aim three alternative scenarios are considered according to a range of possible future renewable energy pathways, leading to baseline, optimistic and pessimistic forecasts.

Once these forecasts are computed we also analyse the emergent professional profiles and required skills related to the new jobs generated in the installation, operation and maintenance of the different renewable energy systems.

Keywords: Renewable energy; Employment forecast; Energy policy; Asturias

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Contents

1. Introduction

The Kyoto protocol of the United Nations Framework Convention on Climate Change (Kyoto, 11 December 1997) has been crucial in promoting the use of renewable energies. Within this framework countries pledged to make substantial efforts in their energy policy in order to reduce their greenhouse gas emissions. In agreement with this goal, the European Union has made the commitment to reduce their emissions by 8% during the period 2008–2012. In order to achieve this objective the European Parliament [3] planned different strategies focusing on renewable energies and stated as a goal that renewable sources should meet 12% of primary energy consumption and increase by 22% the generation of electricity by 2010.

The development of renewable energy industries and saving energy technologies became a way to achieve environmental objectives and a means of increasing energy self-sufficiency and employment (e.g. [4–9]).

However, each country tries to effectively implement renewable energies according to its own characteristics such as energy comsumption, energy diversity or composition of electricity generation. In Spain the Renewable Energy Development Plan 2000–2010 [10], processed by the Industry and Energy Council of the Spanish government and the Spanish Institute for Energy Diversification and Saving-IDEA, is making progress the proposal of the European Commission that renewable sources should cover at least 12% of the total energy consumption by the year 2010. In addition, the plan sets the policies[1] to achieve the objectives of covering 29.4% of the electricity generated with renewable energy plants in the domestic market and 5.75% of the transport fuel consumption with biofuels.

However, since the Spanish autonomous governments[2] are responsible for most of the aspects of the energy sector, they have to design strategies to accomplish the general goals. This article focuses on the experience of the Principality of Asturias in the introduction of renewable energy sources and the technologies of cogeneration and combined cycles.[3]

[1]The main policy differences in the promotion of renewable energies in the EU member states are described in [11].

[2]Spain is divided into 17 regions (autonomous communities), corresponding to the European NUTS 2.

[3]Several studies have reviewed the progress in the introduction of renewable energies in other Spanish Communities such as in Galicia [12] and in Navarra [13]. Moreover, there are more examples at local level worldwide as the study of Cape Verde [14] or Porto Santo [15].

More specifically, we analyse the energy activity in Asturias in order to anticipate the evolution of the employment generated in this sector during the period 2005–2010, mainly focusing on the impact of renewable energies on employment from both a quantitative and a qualitative perspective.

The energy sector has an outstanding role in the economy of Asturias, since it represents 7.4% of the regional gross value added (GVA) and provides 3% of regional employment. This sector is fossil fuel based and the primary energy sources are basically imported (oil and coal) while the local sources come mainly from coal whose related production and associated jobs are declining. The regional coal industry of Asturias has been restructured in order to provide a transition to a competitive environment and the industry based on coal sources has also been adjusted trying to achieve the challenges of stronger environmental regulations.[4] Therefore, the development of renewable energies in this region could become a suitable energy strategy with outstanding environmental benefits, also increasing the use of autochthonous resources with low cost and leading to job gains and net positive impacts on external energy dependence.

In the described context, in order to analyse the perspectives of regional energy employment, we firstly forecast the series provided by the Active Population Survey (EPA) of the Spanish Statistical Institute (INE) [18]. Then, in a second stage we add the expected jobs generated as a consequence of the development of renewable energies, thus obtaining the total forecasted energy employment.

The computation of the employment impacts of renewable energies can be carried out by two different methods: Renewable input–output tables (RIOT) and analytical procedures, based on the estimation of ratios quantifying the expected jobs by unit of installed power. Since the implementation of RIOT methods requires some information difficult to obtain at the regional level, in this work we use analytical procedures.

We take as a reference a basic scenario, defined according to the most likely renewable implementation pathway. Moreover, we consider two alternative scenarios referring to optimistic and pessimistic situations. In the optimistic scenario an additional impetus of renewable energies is considered, leading to wider energy savings and energy efficiency policies, while the pessimistic scenario assumes some delays in the regional projects.

This paper is divided into four additional sections, the first of which contains a brief description of the main characteristics of the energy sector in Asturias analysing input-output tables and energy balances. In the next section we analyse several employment ratios, showing their variability and developing a proposal adapted to the regional characteristics and the available information for Asturias.

Once these regional ratios have been computed they allow us to predict the expected net impact of renewable energy sources on the regional employment during the period 2005–2010, whose results are added to the tendency forecasts and summarized in the third section.

Furthermore, since the use of renewable energies offers major opportunities for job creation, opening a new panorama in professional skills, section four briefly describes the emergent professional profiles in the sector and the corresponding educational necessities.

[4]Some recent experiences in coal industry adjustments have been described referring to Poland and Germany [16,17].

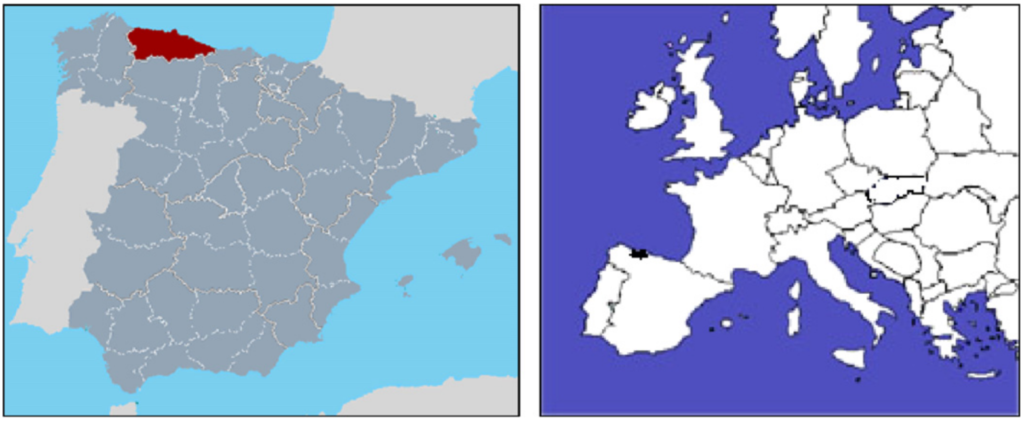


Fig. 1. Location of the autonomous community of Asturias in Europe and Spain.

The work finishes with some concluding remarks and a compilation of bibliographical references.

2. The energy sector in Asturias. An overview

The Principality of Asturias is a Spanish Autonomous Community located on the north coast of Spain (Fig. 1), 77% of its population of 1.1 million inhabitants living in the central area. The economic activity of the region is concentrated on services (62% of the GVA) and industry (23% of the GVA, mainly related to coal-mines and iron and steel industries) while the agricultural sector only generates 3% of the regional GVA [19].

The energy sector represents in Asturias 7.4% of the regional GVA and provides 3% of the regional employment. The Asturian Energy Foundation (FAEN) is the Regional Energy Agency of the Principality of Asturias whose main aim is the achievement of 12% of the energy consumed for domestic purposes to be supplied by renewable sources, as stated by the European Union. This agency also facilitates and collaborates in the realization of the investments programmed in the Spanish Renewable Energy Development Plan 2000–2010 [10], in the drawing up of the Regional Energy Planning 2001–2010 (PLENPA 2001–2010) [20], and in the design of regional energy savings and efficiency strategies.

The regional energy sector is fossil fuel based and the energy-transformation industries are high greenhouse gas emitters.[5] The primary energy sources are basically imported (oil and coal) while the local sources come mainly from coal whose related production and associated jobs are declining. Fig. 2 shows the flow of primary energy and final consumption for year 2004.

[5]As explained in [21], CO_2 is responsible for practically all (99.75%) the greenhouse gas pollution in this region, this fact being closely linked to the production structure. Iron and steel production and the generation of electricity in coal-fired power stations, with highly intensive CO_2 emissions, have a strong presence in the region. Thus, 39% of the emissions correspond to *Coke and petroleum refineries* which include the coke production used basically in steel-making, followed by *Production of electricity* (more than 36%) and, with a much lower percentage, *Household Consumption* (8.2%) and *Other non-metallic mineral products* (6%).

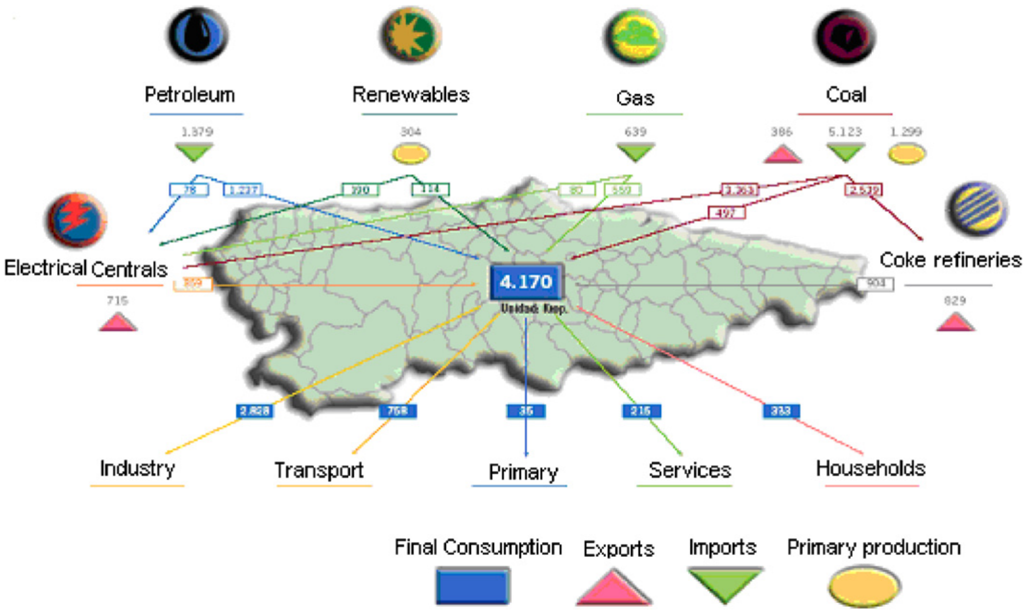


Fig. 2. Energy flows in Asturias. *Source*: Energy Balance of the Principality of Asturias 2004, Asturian Energy Foundation [22].

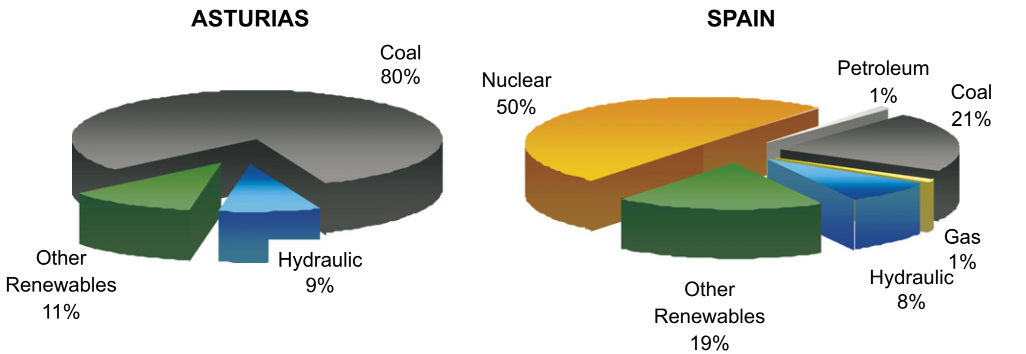


Fig. 3. Primary Production of Energy in Asturias and Spain (2004). *Source*: Energy Balance of the Principality of Asturias 2004, Asturian Energy Foundation [22].

The energy structure of Asturias is quite different from the rest of Spain, as a result of the concentration of coal mines in the regional territory. This situation has a great influence on both the production and the consumption of energy as we show in Figs. 3 and 4.

Moreover, the regional electrical production capacity mainly relies on autochthonous resources such as coal (Coal and Anthracite) and hydraulic power as shown in Table 1.

The analysis of the available Energy Balances [23] shows reductions in coal extraction and hydraulic energy production as a result of the decrease in the rainfall, while other sources progressively increased their weighting.

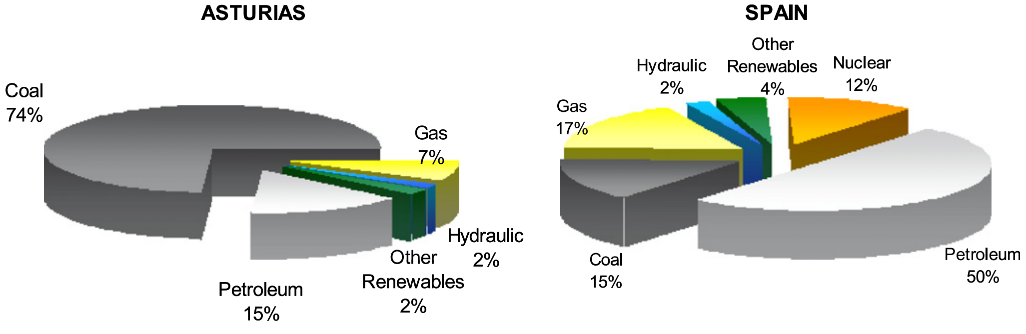


Fig. 4. Primary Consumption of Energy in Asturias and Spain (2004). *Source*: Energy Balance of the Principality of Asturias 2004, Asturian Energy Foundation [22].

Table 1
Production capacity of electrical energy from different types of energy sources in Asturias (Power, MW)

Type of plant	2001	2002	2003	2004
Thermal—coal	2737	2737	2740	2751
Coal	2151	2151	2154	2156
Anthracite	586	586	586	595
Cogeneration	118	124	124	144
Natural gas	37	39	39	48
Waste gases	46	50	50	70
Gas—fuel	26	26	26	26
Hydraulic	725	735	775	783
Minihydraulic	76	81	81	87
Hydro (>10 MW)	649	654	694	696
Biomass	19	32	34	34
Solid urban waste	13	26	26	26
Biogas	6	6	8	8
Wind	24	74	138	144
Photovoltaic—solar	0.21	0.23	0.27	0.32
Total	3623.21	3702.23	3811.27	3866.35

Source: Energy balances of the principality of Asturias, Asturian Energy Foundation [23].

From the point of view of demand, Asturias represents 6.3% of the total energy consumption of Spain, although the regional structure is significantly different from the rest of the country. At the present moment most of the energy demand is concentrated on the basic industry (production of iron and steel and metallurgy) and important energy transformation activities (energy thermal stations and coke refineries) leading to a strong concentration of industrial consumption (representing in Asturias 68.5% of the total consumption, while the national proportion is 37.3%). Another differential characteristic is the high energy primary consumption per capita, since the regional ratio in 2004 was 8.06 tep per capita, which is larger than the Spanish average of 3.88 tep per capita. It must also be stressed that one of the main regional energy problems is a low degree of energy self-supplying, especially in recent years as a result of the reduction in the levels of production of primary energy (Fig. 5).

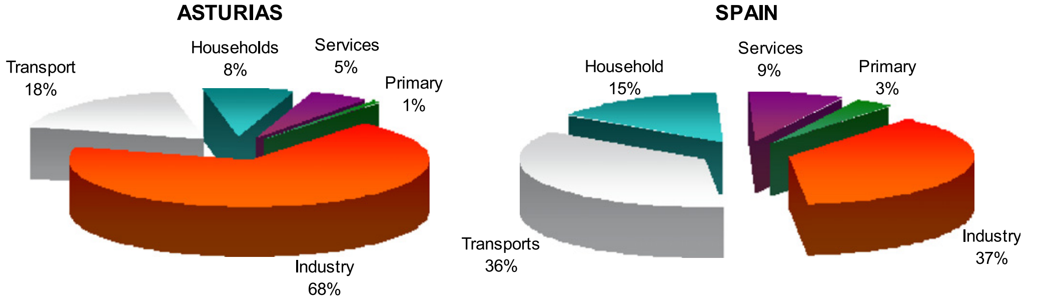


Fig. 5. Final Consumption of Energy in Asturias and Spain (2004). *Source*: Energy Balance of the Principality of Asturias 2004, Asturian Energy Foundation [22].

The input–output tables (IOT) for Asturias published by SADEI (1995, 2000) [24] provide a most complete picture of the energy sector by capturing shifts between sectors and multiplier effects.[6]

This analysis allows the consideration of electrical energy as a key activity according to its relations of supply and demand with the rest of the economic sectors. In particular, the internal purchase index (showing the productive dependency of each activity with regard to the rest of the economy) points out that electrical energy has reversed the downward trend in its use as a result of the increasing use in the region of the energy thermal stations of imported coal. More specifically, the period 1995–2000 registered a 35% increase in coal demand for thermal uses while the regional production of coal decreased by 24%.

Moreover, coke mines have reduced their regional sale index (which measures the dependency of the rest of the economy with regard to the considered activity) since their production shows a greater inclination towards the final demand in detriment of the intermediate demand (coke exports represent a third of the total production).

The outstanding interdependences between energy and the rest of the regional economic activities is confirmed by some other indicators, such as mineral coal activities, iron and steel industry, and even other activities whose relation is not so evident such as retail commerce.

From the point of view of employment, the "employment multipliers" allow analysis of the linear relation between the employment in each branch (L_i) and its output (X_i) according to the expression: $I_i = (L_i/X_i)$. The results for the activities of electrical Energy and Coke refineries are the lowest in the regional economy, both in 1995 and in 2000 and it can also be observed that the direct coefficients of employment between the considered periods have diminished by about 25% in almost all the energy activities.

Those conclusions differ if we consider the total multipliers quantifying the variation in the total employment (direct and indirect) caused by a change in the final demand of a given activity. In this case the activities showing greater total multipliers of employment are found to decrease more. The most extreme cases correspond to coke and petroleum refineries that had the greatest total multiplier of employment in 2000 but their effects are reduced at the regional level as a consequence of their external dependency.

[6]The relationship between energy and other economic activities has been pointed out in several studies such as [25] showing a 10-sector input–output model for the UK and [26] analysing an IOT for Taiwan.

3. Forecasting energy employment in Asturias

The available quantitative information about the regional Energy sector makes it possible to estimate econometric models, including both explanatory national and regional indicators and allows forecasts of the evolution of the energy GVA in Asturias. Table 2 summarizes the economic perspectives provided by HISPALINK[7] for Asturias and Spain regarding the energy GVA and also the total gross domestic product (GDP).

As can be seen, the expected economic evolution is positive both at the regional and national level, although the energy perspectives in Asturias are found to be less optimistic than the national ones. In this context, the promotion of renewable energies becomes an interesting alternative in order to achieve a more dynamic regional energy sector.

At the national level, the Spanish Renewable Energy Development Plan 2000–2010 [10] describes alternative scenarios for the evolution of energy. As summarized in Table 3, these scenarios include the general evolution of the energy sector (tendency and efficiency alternatives) and the promotion of renewable energies (present, likely and optimistic alternatives).

The described scenarios provide an interesting framework to be considered for the development of regional forecasts. Furthermore, the Regional Energy Planning 2001–2010 [20] considers several investments in Asturias such as the construction of four combined cycle plants of 400 MW each one and the promotion of cogeneration technologies.

3.1. Energy employment in Asturias. Evolution and tendency forecasts

Energy employment in Asturias shows a decreasing tendency mainly related to the reduction of activity in the mining industries (coal), as can be seen in the series provided by the Active Population Survey (EPA) of the Spanish Statistic Institute (INE) [18], represented in Fig. 6.

Although this decreasing tendency is expected to continue during the coming years, the aim of this paper is to estimate the impact of renewable energies and new energy technologies on energy employment. More specifically, several different factors should be considered, including the shifts from fossil to renewable energies, the implantation of new technologies in the processes of energy generation (combined cycle plants), the development of new energy infrastructures (gas plants and high tension cables) and the implementation of energy saving and efficiency plans.

3.2. Employment ratios for renewable energies in Asturias

Two different kinds of procedures can be used in order to compute the employment generated by renewable energies. The first option is based on RIOT (renewable

[7]HISPALINK is a regional economic research network (based on the Unit Nations-Link Project) constituted by university research teams from the different Spanish regions, focusing on regional economic analysis and forecasts. Each of the research teams specify an econometric model to estimate its own economic evolution, including annual forecasts and the results are combined in a congruent harmonised model. The HISPALINK-Asturias group includes the authors of this paper and three additional researchers linked to the Applied Economics Department of the University of Oviedo.

Table 2
Forecasts of GVA and GDP annual growth rates (%) for Asturias and Spain

	Year 2006 (%)	Year 2007 (%)	Year 2008 (%)
Energy GVA			
Spain	3.1	2.6	1.7
Asturias	0.3	1.0	1.4
Total GDP			
Spain	3.5	3.3	3.0
Asturias	3.0	3.0	2.9

Source: HISPALINK, Spanish regional economic outlook, Semester Report June 2006 [27].

Table 3
Scenarios reported in the Spanish Renewable Energy Development Plan 2000–2010

Scenarios for the general development of the energy sector	Scenarios for the development of renewable energy
Tendency: Current economic and energy tendencies are included, without considering new energy policies	*Present*: The current growth path in each renewable area is accepted. This will result as insufficient to attain the Spanish goals in the promotion of renewables
Efficiency: Improvements in the efficiency of the final consumption sectors in agreement with the "Spanish Saving and Energy Efficiency Strategy 2004–2012." Are included	*Likely*: The renewable evolution in agreement with the present situation and the possibilities of growth in each renewable area, is a probability
	Optimistic: The potentially high growth thresholds attainable in each renewable area, can be attained

Source: Spanish Renewable Energy Development Plan 2000–2010 [10].

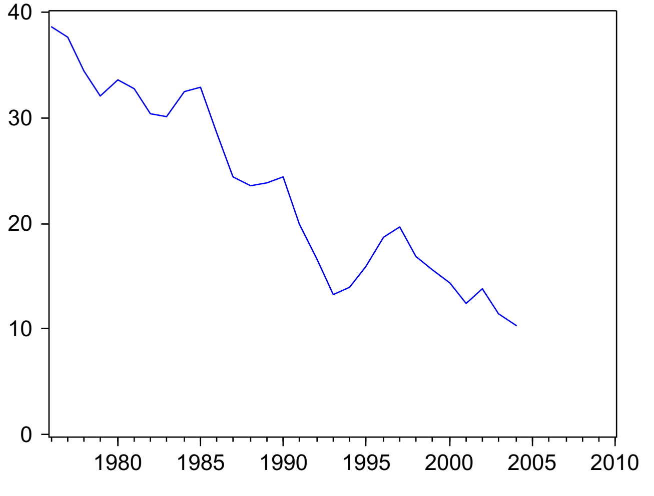


Fig. 6. Evolution of energy employment in Asturias (thousands of jobs). *Source*: Active Population Survey (EPA), Spanish Statistic Institute (INE) [18].

Table 4
Job creation from renewable energy development in the European Union and Spain since 1995

Renewable energy	European Union-15		Spain	
	2010	2020	2010	2020
Solar—thermal	7390	14 311	2264	3866
Solar—photovoltaic	−1769	10 231	849	2694
Solar—thermoelectric	649	621	649	621
Wind	12 854	28 627	7701	8480
Minihydraulic	−995	7977	1732	3125
Biofuels	70 168	120 285	3007	6103
Biogas	27 582	37 271	340	728
Biomass	128 395	165 860	7446	11 536
Biofuel production	416 538	515 364	20 982	47 245
Total	660 812	900 546	44 970	84 397

Source: The European Renewable Energy Study—II (TERES II) [30].

input–output tables) while the second focuses on analytical methods generally based on the estimation of employment according to a ratio by unit of renewable installed power.

The first alternative requires ample information, and thus it is generally applied at aggregate level as in the European Union or its members, its application being very limited in regional studies. Therefore, the European Union Commission sponsors several projects financed by the ALTENER programme[8] using RIOT methods to quantify the employment derived from the penetration of the diverse renewable technologies.

These projects include the TERES II and MITRE initiatives and the experience gained from them can be very helpful for our purposes.[9] More specifically, TERES II [28–30] provides projections on energy development and policy implications for the years 2010 and 2020 and predicts the jobs that will be created in the EU and its members in pursuing the target of 12% share provided by renewable energy sources in energy consumption. According to this project, 60000 jobs are expected in Spain as we show in Table 4.

As we have previously said, RIOT models are difficult to apply to local markets due to the limitations of disaggregated information. Therefore analytical methods are often used, providing the direct employment impacts due to each renewable technology investment such as manufacturing, delivery, construction and installation, and operation and maintenance. However there is no unanimity in the considered ratios and some outstanding differences can be observed among them, as is shown in Table 5.

[8]The European Commission also coordinates some other programmes related to renewable energies and energy efficiency: SAVE projects to exploit the immense potential of energy savings, particularly in buildings and industry, STEER projects to promote the more sustainable energy use in transport (i.e. increased energy efficiency, new and renewable fuel sources, and the adoption of alternatively propelled vehicles) and ALTENER projects helping to increase the use of new and renewable energy sources and to speed up policies for sustainable energy. The emphasis is on the promotion of both central and local production of electricity and/or heat, as well as its integration into local energy systems.

[9]TERES II is the acronym for The European Renewable Energy Study II while MITRE Project refers to Monitoring and Modelling Initiative on the Targets for Renewable Energy.

Table 5
Employment ratios for renewable energy sources ("construction and installation" and "operation and maintenance")

Renewable energy	Construction & installation ratio	Operation & maintenance ratio	Units	Study
Wind	6.0		MW	Sustainable Energy Authority, Victoria
	2.6	0.2	MW	Electric Power Research Institute, Renewable Energy Office of the California Energy Commission
	0.4	0.3	MWa	Renewable Energy Policy Project, 2001
	2.5	0.3	MWa	EWEA/Greenpeace European Wind Energy Association, 2003
	0.2	0.1	MWp	Renewable Energy Policy Project, 2001
	0.9	0.1	MWp	EWEA/Greenpeace European Wind Energy Association, 2003
	14.0		MW	Greenpeace Germany (1997)
	22.0		MW	Windforce 10 : EWEA, Green Peace and the Forum for Energy and Development (October 1999)
	15.0	0.1	MW	European Commission Directorate-General for Energy "Wind energy-the facts: Volume 3: Industry&employment" (1997)
	13	0.2	MW	Spanish Renewable Energy Development Plan 2000–2010, IDAE
Hydroelectrics	18.6	1.4	MW	Spanish Renewable Energy Development Plan 2000–2010, IDAE
Geothermal	4.0	1.7	MW	Electric Power Research Institute, California
	17.5	1.7	MW	Renewable Energy Office of the California Energy Commission
Solar—photovoltaic	7.1	0.1	MW	Electric Power Research Institute, California
	6.2	1.2	MWa	Renewable Energy Policy Project, 2001
	5.8	4.8	MWa	Greenpeace, 2001
	1.3	0.3	MWp	Renewable Energy Policy Project, 2001
	1.2	1	MWp	Greenpeace, 2001
	82.8	0.4	MWp	Spanish Renewable Energy Development Plan 2000–2010
Solar—thermal	5.7	0.2	MW	Electric Power Research Institute, California
		1.1	MW	Sunray Energy Solar Thermal Power Plants
	16.64	1.664	Meuros	Spanish Renewable Energy Development Plan 2000–2010, IDAE
Solar—thermoelectrics	44.4	2	MW	Spanish Renewable Energy Development Plan 2000–2010, IDAE
Biofuels	3.7	2.3	MW	Electric Power Research Institute, California
	0.4	2.4	MWa	Renewable Energy Policy Project, 2001
	0.3	0.4	MWp	Renewable Energy Policy Project, 2001

Source: Own elaboration from [10,31–38].

Besides the observed heterogeneity in the reported ratios, it must be noticed that each proposal refers to a specific case, thus the geographic characteristics vary according to where the investment is placed, the particular company projects and even the units of measurement. Therefore we should study the specific renewable projects linked to Asturias in order to estimate the most suitable ratios for this region. The information provided by the Regional Energy Foundation FAEN and the Spanish Renewable Energy Development Plan 2000–2010 [10] leads to the employment ratios summarized in Table 6.

The application of these ratios to the regional renewable energy installations will provide the expected employment linked to renewable energies as we describe in the next section.

Table 6
Regional employment ratios for renewable energy sources in Asturias (''construction and installation'' and ''operation and maintenance'')

Renewable source	Unit	Construction & installation	Operation & maintenance
Wind	MW	13	0.2
Solar—thermal	Thousand m^2	2.5	5
Solar—photovoltaic	MWp	34.6	2.7
Biofuels	1000 T/year	5	1.5
Hydro	MW	18.6	1.4
Biomass—thermal	tep	0.12	0.01
Biomass—electric	MW	4	0.14
Biogas	MW	25	6

Source: Own elaboration from Spanish Renewable Energy Development Plan 2000–2010 [10] and Asturian Energy Foundation.

Table 7
Expected evolution of Regional Energy Power in Asturias 2005–2010

Renewable	Situation at 31/12/2004	Δ 2005–2010		
		Baseline scenario	Optimistic scenario	Pesimistic scenario
Wind	144 MW	605 MW	756 MW	305 MW
Solar—thermal	9022 m^2	30 905 m^2	41810 m^2	20 000 m^2
Solar—photovoltaic	349 KWp	3000 KWp	4000 KWp	2000 KWp
Biofuels	3600 T/year	4000 T/year	8000 T/year	0 T/year
Hydro	87 MW	5 MW	10 MW	0 MW
Biomass—thermal	114 354 tep	1200 tep	1630 tep	860 tep
Biomass—electrical	26 MW	0 MW	35 MW	0 MW
Biogas	8 MW	1 MW	1 MW	0 MW
Cogeneration	100 MW	10 MW	169 MW	0 MW
Combined-cycle				
Construction	0 MW	1200 MW	800 MW	1600 MW
Operation	0 MW	800 MW	1200 MW	400 MW
Regasification plant		Operation	Operation	Construction

Sources: Revised Spanish Planning of the Electricity and Gas Sectors 2002–2011 [41], Spanish Renewable Energy Development Plan 2000–2010 [42] and Asturian Energy Foundation.

3.3. Scenarios for energy employment in Asturias

The definition of alternative scenarios for energy in Asturias 2005–2010 has been carried out by taking into account the national framework provided by the Spanish Renewable

Table 8
Job creation from renewable energy development in Asturias over the period 2005–2010 under different scenarios

	Baseline scenario	Optimistic scenario	Pessimistic scenario
Wind	7986	9979	4026
Construction and installation	7865	9828	3962
Operation and maintenance	121	151	61
Solar—thermal[a]	181	247	115
Construction and installation	27	37	100
Operation and maintenance	155	209	15
Solar—photovoltaic[b]	67	99	52
Construction and installation	60	89	47
Operation and maintenance	7	10	5
Biofuels	6	85	0
Construction and installation	0	75	0
Operation and maintenance	6	10	0
Hydro	93	186	0
Construction and installation	86	172	0
Operation and maintenance	7	14	0
Biomass—thermal	43	58	33
Construction and installation	34	47	24
Operation and maintenance	8	11	6
Biomass—electrical	0	405	0
Construction and installation	0	400	0
Operation and maintenance	0	5	0
Biogas	31	31	0
Construction and installation	25	25	0
Operation and maintenance	6	6	0
Combined cycles	2660	2700	2640
Construction and installation	2600	2600	2600
Operation and maintenance	60	100	40
Cogeneration	10	87	0
Construction and installation	0	68	0
Operation and maintenance	10	19	0
Regasification plant	1120	1120	1000
Construction and installation	1000	1000	1000
Operation and maintenance	120	120	0

[a]According to the information provided by FAEN and since not all the planned installation will contribute to job creation, the jobs related to solar-thermal energy have been computed by applying the employment ratios to 10 665, 15 310 and 6020 m^2 in the baseline, optimistic and pessimistic scenarios respectively.

[b]In the case of solar-photovoltaic energy the expected generated jobs have been computed by applying the employment ratios to 1729, 2582 and 1350 KWp in the baseline, optimistic and pessimistic scenarios respectively.

Table 9
Forecasts of energy employment in Asturias (annual average EPA)

Year	Baseline scenario	Optimistic scenario	Pessimistic scenario
2005	10 004	10 011	9996
2006	10 025	10 042	9993
2007	10 060	10 105	9994
2008–2010	10 511	10 707	10 198

Energy Development Plan [10] and also the regional context, which is quite uncertain.[10] Therefore, different rhythms of development have been considered, leading to three alternative scenarios. The baseline alternative considers the construction of three combined cycle plants although only two of them may begin to operate, also some energy transportation activities and the construction of a gas plant are thought of as possible.

In the baseline and the optimistic scenarios a gas plant could start its operations at the end of the considered forecasting period, as it is thought in the revision of the Spanish Planning of the Electricity and Gas Sectors 2002–2011 [41]. Furthermore, the optimistic scenario assumes that the Spanish Savings and Energy Efficiency Strategy 2004–2012 [42] will begin to have effect in 2007. Contrariwise, the pessimistic scenario considers that these policies will not begin to be effective before the year 2010, and there will be a delay in the construction of the gas plant.

In this context, Table 7 summarises the expected evolution of regional energy power during the period 2005–2010 according to the defined scenarios.[11]

The application of the regional employment ratios to these energy power scenarios leads to the expected employment generated by renewable energies in Asturias over the period 2005–2010, whose results appear in Table 8.

As it can be seen, most of the employment generated by the development of renewable energies corresponds to Construction and Installation, while the maintenance employment (which is quantitatively less) is strictly related to the energy sector, which is our main objective. The addition of the employment specifically linked to the energy sector to the previously obtained tendency forecasts leads to the final results collected in Table 9.

In general terms, these results confirm that, as expected, the development of renewable energies compensates the gradual loss of employment in the traditional extractive industries, leading to an expected employment which varies from 10198 to 10707 persons in the considered scenarios.

4. Identification of new jobs in the field of renewable energy

As we have already seen, renewable energies have the potential to become a significant source of jobs in Asturias, opening employment opportunities in a wide variety of fields. Furthermore, the employment in renewable energies requires some skills that do not

[10]Some other studies analyse energy scenarios according to different strategic planning and energy analysis [39,40].

[11]The total published in the table collects the expected installed power for the coming years but not the installed power in 2010 as it does not include the power currently installed.

Table 10
Skills and professional profiles linked to renewable energies employment

	Skills	Professional profiles
Wind planning offices	Research of appropriate sites for wind energy Negotiation with the involved groups Research of investors and shareholders Planning of the wind parks (technical and legal) Surveillance of the wind-park construction Exploitation or selling of the finished parks Acquisition of foreign sites	Engineers Lawyers Financial experts General administration staff
Weather Survey and Environmental Impact Survey Offices	Measurements of weather data on site Data preparation Spatial planning expertise Environmental impact calculation Measurements of sound emissions	Spatial planners Meteorologists, geologists, biologists, statisticians and others, Surveyors, General administration staff
Energy Finance Service Providers and Bond Brokers	Fund raising Contract negotiation Project acquisition Market surveys Organization of local investment bonds (administration and service for the share holders) Financial and economical consulting Communication of new bonds	Bankers Consultants Lawyers or legal assistants Renewable energy market specialists Public relation specialist Shareholder relation manager General administration staff
Gas fired Plant Safety Inspector	Verify the safety of natural gas installations Check that gas equipment and pipelines conform to legal requirements Raise awareness among the local administrations and the general public about safety problems, accident prevention and good maintenance behaviour Act as consultants on technical norms and regulations regarding safety and accident prevention behaviours for local authorities	Technical knowledge of mechanical engineering and design of plants with moving fluids (university level) In-depth knowledge of laws, norms, regulations and authoritative procedures
Renewable Energy Researcher	Proven good technical and technological knowledge as far as environment, renewable energy and industry are concerned Managing and organizational skills Sufficient knowledge of economic parameters involved in energy production and consumption	University

Table 10 (*continued*)

	Skills	Professional profiles
	Good human relations, communication and presentation skills Proven experience in developing and implementing energy related and environmental projects	
Technical Surveys Offices and Operation and Maintenance Service Providers	Technical maintenance Repair of broken components General inspection of renewable energy installations Emergency service Remote monitoring of the installation performance	Technicians (electronic, electro-technical, thermal energy technology) General administration staff
Renewable Energy Project Management and Project Auditing Firms	Renewable energy consulting Market surveys Project structuring, project management consulting Project monitoring Financial Modelling and project finance consulting Renewable energy risk management Due Diligence Model Audit	Consultants Renewable energy market specialists Project managers Economical and financial experts General administration staff
Photovoltaic and Solar Thermal Manufacturers	Production and marketing of solar thermal and photovoltaic equipment	Engineers, scientists, sales managers, production managers Financial and legal experts Administration and management staff
Renewable Energy Producers and Suppliers	Purchase and sale of green electricity and renewable fuels Calculate the clients' electricity consumption and match demand with offer	Sales, engineers, chemists, biologists General administration staff
Building Energy Inspector	Evaluate the energy performance of buildings Find out the important energy losses of a building Suggest measures to be taken in order to save energy	Engineering education Good knowledge of thermodynamics and heating Installations Basic knowledge of capital investment budgeting

Source: Own elaboration from [43][a].

[a]This report is a summary of collected data about new professions and new business sectors in the field of renewable energy and rational use of energy in Germany, France, Greece and Italy. It contains job descriptions, business branch information and some additional data such as host structures for the new jobs and firms in the new business fields.

coincide with those related to the traditional sector, thus suggesting the convenience of identifying these new necessities and requirements.

In this section we analyse and identify the emerging occupations linked to the development of new energies in Asturias in order to detect the possible difficulties to cover them with our local labour market.

Professional skills are defined as "the combination of knowledge, necessary abilities and attitudes in order to achieve the required results", or "the real capacity of the individual to dominate a set of tasks to develop a specific job". By defining what are the abilities required by the new jobs we can test if there are sufficient workers in our region whose training fits the required profiles.

The obtained results show that the development of the energy sector will have an important effect on construction jobs. Since construction in Asturias is undergoing a boom expected to continue during the coming years with the consequent demand for workers, this activity could face the risk of a lack of available professionals during the coming years.

Further, the job requirements directly linked to the energy sector include two levels of specialization. The first of them corresponds to the technical profiles whose fundamental tasks would be to plan and execute projects. The demanded profiles would be preferably technicians in the fields of mechanical and electro-technical engineering but also those related to economics, management and administration. On the other hand, it is necessary to consider the professional profiles related to the energy efficiency policies that could generate about 160 jobs in Asturias. A summary of these professional skill requirements is presented in Table 10.

The second level of employment would correspond with installers and operation and maintenance workers. Since in Asturias thermal and photovoltaic solar energies are expected to have a great development, educational planners should revise their strategies in order to supply professionals in electrical and plumbing contracting, architecture and system design, battery and electrical equipment among others. Currently, the educational council of the Government of the Principality of Asturias offers the professional studies summarized in Table 11.

Table 11
Professional studies in the field of renewable energies in Asturias

Course description	Skills	Required educational level
Thermal solar installers	To install solar collectors according to the specific conditions of the area where they are going to be used To determine size collectors To be able to check and control their operation To provide technical support, during their operation. To revise antifreeze fluid To analyse efficiency curves	Thermal installations [44]
Photovoltaic and wind energy installers of low power	To install autonomous Electrification systems from thermal solar energy Measure panels and batteries To design installations To detect problems To monitor maintenance	Electrical/electronic of low tension [45]

Source: Own drawing up from [46].

Table 12
Professional profiles of the forecasted new jobs generated in the regional energy of Asturias 2005–2010

	Baseline scenario	Optimistic scenario	Pessimistic scenario
Thermal solar collector installers	137	185	86
Photovoltaic solar installers	50	74	39
Engineers, architects and lawyers	59	78	27
Workers in operation and maintenance	295	386	97
Administrative and commercial staff	46	59	25
Total energy sector	587	782	274

Taking into account the skill requirements in renewable employment our educational planners must guarantee the opportunities in the educational system for people to have the chance of obtaining the qualifications for these new jobs, especially if the high level of employment possibilities for these professional profiles [47].

Table 12 quantifies the new jobs in energy generated during the period 2005–2010 in Asturias by professional profiles, according to the previous forecasts obtained in different alternative scenarios.

5. Conclusions

In this paper we have examined the perspectives of energy employment in the Principality of Asturias (Spain) during the period 2005–2010, mainly focusing on the employment generated by renewable energies, which has been computed by regional ratios of job per unit of installed energy power.

The energy perspectives have been examined in three alternative scenarios according to a range of possible different energy policies, saving and efficiency strategies and evolution of renewable technology investments in Asturias. The results show that the main job creation in our region is related to thermal and photovoltaic solar energy and wind energy.

The obtained forecasts show that the development of renewable energies will have an outstanding effect on employment, thus compensating the gradual losses in employment in the traditional mining industries. Moreover, renewable energies are expected to create more jobs in Construction and Installation than in Operation and Maintenance, thus facing the risk of a lack of available construction professionals during the coming years.

The work also includes a skill requirement analysis which has two levels of specialization, the first relating to technical and engineering skills while the second refers to installers, thermal and photovoltaic solar paddles basically.

Asturias has to face the challenge and adapt its energy sector to the new framework characterized by changes both in the energy supply (impetus of renewable energies, new transport infrastructures and electricity generation technologies) and in its demand (saving and power efficiency) and also in the regulation of the sector.

In this context, future government policies and private initiative should adopt strategies to satisfy the requirements of the energy sector, including the training of future workers, thus improving regional competitiveness and generating positive effects on the regional labour market.

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